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微波陶瓷的卡拉胶凝胶注模成型技术

Near-Net Shaping of Microwave Ceramics  
by Gel-Casting with Carrageenan

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## 摘 要

凝胶注模成型工艺是近几十年发展起来的一种近净尺寸原位凝固成型技术，目前已广泛地应用到结构陶瓷的制备加工。微波介质陶瓷是使用在微波频段下的重要功能陶瓷，本论文首次将卡拉胶凝胶注模成型技术引入到微波陶瓷的成型工艺，制备出了形状复杂、性能优良的微波陶瓷元器件。

本论文系统地研究了微波陶瓷的卡拉胶体系凝胶注模成形工艺，包括高固相含量低粘度浆料的制备、凝胶机理及过程的控制、坯体的干燥和烧结、陶瓷的显微形貌与微波性能等，在此基础上利用卡拉胶凝胶注模成型方法成功地制备出了若干陶瓷坯体，实验表明此法对陶瓷微波性能没有不良影响，但是坯体的强度有待提高。针对卡拉胶在凝胶注模成型过程中体现出的缺点和不足，实验在设计加工多种复杂形状模具的同时，从工艺方面进行探讨，提出了两种改进方法，分别从凝胶物质(复合胶)和凝胶成型条件两方面对原工艺进行了改进，取得了良好的效果。实验中结合目前通讯技术的发展要求，利用卡拉胶凝胶成型工艺成功地制备出一款百孔陶瓷滤波器，并完成电极制备工序，进行电容性能的测试，结果表明符合标准文件 MIL-C-38999 II 系列 (22-35)。

论文最后对卡拉胶微波陶瓷凝胶注模成型技术中的一些问题进行探讨，重点分析了新的成型工艺原理，并对卡拉胶凝胶注模技术的发展提出了几点看法。

**关键词：**微波陶瓷；卡拉胶；复合胶；凝胶注模成型；陶瓷滤波器



## Abstract

Gel-casting is a novel technique for near-net-shape manufacturing of complex ceramics, which has been widely used in the formation of structural ceramics. Meanwhile microwave dielectric ceramics (MWDC) is one kind of important functional materials for wireless technology. In this thesis, gel-casting with carrageenan was applied to shape MWDC with complex structure and corresponding microwave components in the first time.

Gel-casting of MWDC with carrageenan was systematically studied, including the preparation of slurry with high solid loading and low viscosity, process controlling of gelation, drying and sintering of greenbody, and the microstructure as well as properties of ceramics. Moreover, several kinds of complex components of MWDC were also formed, based on the carrageenan characteristics of rheology and gelling. Though the density of green body was rather low, the microwave dielectric properties of the MWDC were good. In order to overcome the shortage in the gel-casting with carrageenan, two new solutions were proposed and applied into execution, which were improved in the two aspects of gelable materials (complex colloidal) and gelable conditions. As an example of microwave devices, one kind of dielectric ceramic filter with 100 holes was prepared by these techniques with carrageenan. The results indicated that dielectric parameters agree with the standard of MIL-C-38999 II (22-35).

At the end of this thesis, some problems in gel-casting of MWDC were discussed, especially the theories of these techniques. And some new ideas were also put forward about the development of gel-casting with carrageenan.

**Keywords:** MWDC; Carrageenan; Complex Colloid; Gel-casting; Ceramic Filter





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